7. WFC3 in the Broader Context of NASA and Ground-Based Astronomy

The next decade marks an important transition in astronomy. A number of sensitive, ambitious sky surveys are being undertaken in the UV, optical, and IR bands both in space and on the ground. NASA will be placing a great deal of emphasis on infrared astronomy, for which the premier instrument by 2010 will be NGST. Two of HST's most important roles in the 2004-2010 period will be to exploit the rich return from the new sky surveys and to serve as a bridge to the next generation of powerful instrumentation. In this section we address the contributions of WFC3 in the context of other space- and ground-based initiatives.

7.1 Major UV, Optical, and Infrared Programs

(a) Next Generation Space Telescope

The Next Generation Space Telescope (NGST) will have an 8 meter aperture covering the wavelength range from 1 – 5 □m (with a stretch goal of 0.5 to 30 □m) and a planned lifetime of 5 – 10 years. Its spectral coverage includes the WFC3/IR range. It is currently slated for launch in 2009 to a location at the second Lagrangian point of the Earth-Sun system. The instruments on board will include cameras and spectrometers, but the specific instruments have not yet been selected. Its combination of large collecting area, cool optics, high quantum efficiency, and large field of view (~240 arcsec × 240 arcsec) provides scientific opportunities that extend well beyond the capabilities of HST.

WFC3/IR can serve as a scientific bridge to NGST and it should undertake as much of the basic exploration of the high-resolution, near-infrared universe as possible, leaving NGST free to emphasize those critical projects for which it is essential.

(b) Stratospheric Observatory for Infrared Astronomy

SOFIA is a 2.5-meter infrared telescope which will be flown on a Boeing-747. It is scheduled to begin operation in late 2002. It will have spectral coverage from 0.3 – 1000 □m, but with seeing limitations to •2 arcsec in the 0.3-2 □m band. The high spatial resolution of WFC3 will be complementary to SOFIA in the overlapping wavelength range.

(c) Space Infrared Telescope Facility

SIRTF is a 0.85-meter, cooled infrared telescope with a field of view of 1.8 degrees, scheduled for launch in December 2001. It has a planned lifetime of 2.5 - 5 years and will cover the range from 3 - 180 □m. Its cameras have low spatial resolution (about 2 arcsec). Thus, WFC3-IR and SIRTF offer complementary capabilities from the standpoint of both resolution and spectra coverage.

(d) Far Ultraviolet Spectroscopic Explorer

FUSE is an ongoing mission offering high resolution spectroscopy at far-ultraviolet wavelengths between 900 and 1200 Å. Its optimized for brighter, stellar targets. Its capabilities are entirely complementary to WFC3/UVIS.

(e) Space Interferometry Mission

SIM is a mission aimed at obtaining high accuracy astrometric measurements of sources across the sky and at obtaining extremely high angular resolution images. Its emphasis will be on very high angular resolution for relatively bright, visible light sources in selected, small, fields. There is no direct overlap with WFC3 capabilities, although the combination of WFC3 and HST's astrometry Fine Guidance Sensor (FGS) could prove useful as finder probes of important SIM fields.

(f) Galaxy Evolution Explorer

The GALEX mission will make a deep, low spatial resolution (5 arcsec) UV survey of the sky. This will be the first all-sky UV survey since TD-1, which reached only 9th magnitude and did not detect a single galaxy or QSO. GALEX should detect galaxies down to ~21 mag. WFC3 will provide the ideal means for obtaining deeper, higher-resolution follow-up observations of GALEX detections, particularly in the case of interacting galaxies or groups and clusters of galaxies.

(g) Two Micron All Sky Survey

The Two Micron All Sky Survey (2MASS) is a near-infrared (1.2 □m – 2.2 □m) survey of the entire sky. The survey employs highly automated 1.3-meter telescopes at Mount Hopkins Observatory for the northern hemisphere and at Cerro Tololo Inter-American Observatory for the southern hemisphere. It is reaching limiting magnitudes of ~15 in H. The survey should be completed in the course of the year 2000. WFC3-IR is able to image sources more than 10 magnitudes fainter than 2MASS and thus it is ideally suited to carry out follow-up observations of sources that are discovered by 2MASS.

(h) Sloan Digital Sky Survey

The Sloan Digital Sky Survey (SDSS) is a ground-based imaging and spectroscopy program to survey approximately 1/4 of the sky using 5 filters in the range 3500 - 9100 Å. The limiting AB magnitude is 22.6 in the Gunn g filter (4800 Å). Over 100,000,000 astronomical objects, mostly galaxies, will be cataloged. The survey should be completed around the year 2003. WFC3 includes the Sloan filters in its filter complement. Both WFC3 and ACS will be prime instruments for high-resolution imaging follow-up of important discoveries by the SDSS. WFC3 is especially important for extending ACS wide-field coverage into the near-UV and near-IR spectral ranges.

(i) Far Infrared and Sub-millimeter Telescope

The Far InfraRed and sub-millimeter Telescope is an European Space Agency-led mission planned for launch in 2007 and covering the wavelength interval 60-670 □m. FIRST main goals are the study of star formation in dust-enshrouded environments both in the local universe and at high redshift, the physics of the interstellar medium, and solar system investigations. Its science capabilities and goals are complementary to those of WFC3.

(j) Chandra X-ray Observatory

The Chandra X-ray observatory was launched in July 1999. Chandra has a spatial resolution of 0.5 arcsec, and is capable of imaging and spectroscopy in the energy range 0.1-10 keV (1-100 Å.) WFC3 will complement Chandra by allowing the identification of visible/near-infrared counterparts of Chandra sources. In particular, WFC3 will allow the identification of the parent galaxies of dust obscured AGNs, clarify ISM and IGM processes, shed light on the hyper-novae paradigm for Gamma Ray Bursts, allow detailed mass modeling of galaxy clusters.

(k) Adaptive Optics on Ground Based Telescopes

Natural guide-star adaptive optics (AO) systems are now being developed on 8- and 10-meter telescopes. These systems perform best in the near- and mid- IR, but significant corrections can be achieved over the wavelength range spanned by the near-IR channel on WFC3. Presently available AO systems, and those expected in the next several years, have limited fields of view (~30 arcsec) and Strehl ratios well below unity. The wide field, low background, and uniform and stable diffraction limited PSF provided by the WFC3 offer complementary capabilities when compared to AO from the ground. Perhaps the greatest promise of ground-based adaptive optics systems lies in near-IR spectroscopy, where the impact of the background can be minimized by observing between the atmospheric OH lines. WFC3 can play a vital role in identifying appropriate targets for AO-fed spectrographs on US and international 8 to 10 meter telescopes in the years before the launch of NGST.

8. Conclusions

WFC3 is a two-channel camera covering the wavelength interval 2000-17000 Å, a broader interval than that of any previous instrument on the Hubble Space Telescope. Its high sensitivity and large field of view will open up a large new volume in discovery space and allow WFC3 to provide fundamental contributions to a broad array of science problems, including many open problems within NASA's Origins theme. In particular, WFC3 will be able to establish the star formation history of nearby galaxies, to follow the assembly of galaxies during the period of peak star formation and metal production activity 8-12 billion years ago, to explore the birth and death of stars, to study water ice on Mars and the meteorology of the giant planets in the Solar System, and to place constrains on the *End of the Dark Ages* – the high-redshift epoch when the Universe become transparent to ultraviolet photons.

The compelling science made possible by the panchromatic WFC3 will assure that HST will continue to provide forefront science through the end of its mission, and will provide a natural stepping stone from current state-of-the-art capabilities to those of the NGST era.